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(54) APPARATUS FOR LIFTING AND/OR LOWERING LOADS

(71) I, RUDOLF VOGEL, of 6 Jaegerweg, 332 Salzgitter 51, Germany; a German national, do hereby declare the invention, for which I pray that a patent may be granted to me, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The invention relates to an apparatus for lifting and/or lowering loads, such as a lift cabin, in which the load to be moved is supported by a flexible member or members passed around a drive pulley, drum or rollers.

In some known apparatus of this kind the load is suspended on cables. Hydraulic lifts are also known, the load of which is supported on hydraulic lifting pistons. Besides these two supporting means, steel link chains, screws and racked bars are used for special lift structures. The two mainly used systems are cable lifts and hydraulic lifts, the cable lift being the predominant one.

In cable lifts, which nowadays are exclusively constructed with a pulley drive, it is known that at least three cables are necessary per installation, the cables being subject to a plurality of static and dynamic stresses, and that furthermore the magnitude of these cannot be accurately determined. In addition wire cables operate fundamentally to a time-strength programme which signifies that the life of the cables is limited. Hydraulic lifts only act relatively slowly over limited lifting heights.

The object of the present invention consists in over-coming the disadvantage of known lifting devices, e.g. of known lifts, more particularly wire cable lifts and to provide a lift system using tested means which permit considerable lifting heights to be reached safely and at high travelling speeds.

According to the present invention there is provided apparatus for lifting and/or lowering loads, comprising a load carrier supported by means of at least one thin, flexible spring steel strap passed round and driven by a drive pulley, drum or rollers coupled to drive means. The cross-section of the supporting straps is of particularly simple form in contrast to the complex structure of the cross-section of the wire cables in cable lifts and so permits the calculation and hence the control of the correspondingly simple supporting strap stress. Furthermore, the sample supporting strap cross-section during manufacture of the straps permits even the smallest faults and damage to be reliably noticed and eliminated. The strap is so dimensioned that the maximum stress lies below the elastic limit of the strap material. Renewal of straps is hence no longer necessary, or it may occur at increased time intervals, as compared with cables.

The supporting strap or straps are passed round a pulley or several rollers or wound on a drum. Such pulley, rollers or drum may be driven by positive or frictional engagement; a lift installation may be made with or without a counterweight.

To enable small roller diameters to be used, the ratio of strap width relative to strap thickness is large, with a small thickness of the strap. This enables a reliable design of strap cross-section with its carrying capacity, the modulus of elasticity of the strap material and the radius of the roller. Such that the normal tension from the load and the bending tension from the reversal are of substantially the same order of magnitude.

When several straps are provided per installation, these may be located side by side with their edges adjacent to one another. This method of location of the straps permits the use of either drive pulleys or a drum. The use of a counterweight may be omitted when a drum is used. The straps may also be spirally stored in superposed plies on a drum.

In a cable-type lift (one in which the load bearing strap is in tension) in which the means for operating the pulley or drum is combined with the pulley into an operating unit, the operating unit may be located on the roof of the lift cabin. This eliminates interfering superstructures on the roof of the operating building. Maintenance and inspection of the mechanical devices of the operating unit may

be safely carried out from a floor or in a more easily accessible cellar of the operating building; moreover the positions of the control switch in the cabin of the lift and the operating unit on top of the cabin remain relatively unchanged; their mutual spacing is short enough for any conceivable control system, e.g. a mechanical or pneumatic system may be employed.

A further improvement in accordance with the invention is obtained in that the supporting spring steel strap is longitudinally precurved when not under tension, the radius of pre-curvature being equal to or larger than the radius of curvature of the pulley over which the spring steel strap passes. This provides three advantages. The overall stressing of the strap is less than with conventional methods; the strap lits readily against the driving pulley, more particularly when the load is light; finally, in installations in which the strap is wound on a drum a reduction of the bending moment is obtained. The longitudinal pre-curvature of the strap may, however, also be used to keep the diameter of the pulley or the drum small, which has considerable resultant advantages for the driving elements.

According to another feature of the invention, the strap when passing over a pulley has an outwardly directed transverse curvature imposed thereon which on leaving the pulley disappears. By this means the strap or straps are self-centering during operation without having to make use of the rims of the pulley. Moreover, the lateral edges of the strap are additionally subject to a compressive stress, which contributes to the suppression of cracking, which as shown by experience emanates only from the edges. Finally, a cross-tension state is formed in the central region of the strap which relieves the longitudinally directed main stresses on the outer and inner surfaces of the strap.

The surface of the pulley may have a facing or friction layer applied thereto which drives and supports the strap. In this manner a minimum coefficient of friction between strap and foundation, with temperature changes, surface pressure, moisture and operating period, may be established for the drive. Furthermore, wear of the surface of the strap is reduced and hence an increased operational safety and operating period is obtained.

In apparatus in which the load carrier is suspended from a number of steel straps laid flat, one upon the other, provision is made for compensating for the difference between the effective lengths of the individual straps which occur over the range of travel of the load carrier, said differences being due to the winding of one strap over the other on the drive pulley, drum or rollers. Means for effecting such length compensation consists, in one example thereof, of two parallel members of a parallelogram linkage which are separately and pivotally mounted on a portion of the load carrier, the two other members of the linkage being pivotally connected, respectively, to the load ends of one pair of two pairs of straps by which the load carrier is suspended. With the aid of such compensating means, the differences between the effective lengths of individual strap, or pairs of straps, are continuously compensated for over the entire range of travel of the load carrier, with the result that the strap on their way round the driving pulley, drum or rollers do not chafe one another, but are passed round the pulley, drum or rollers without sliding. This leads to maximum preservation of and uniform distribution of the load on the straps.

Usually the moving parts of a lifting device, e.g. a lift, are guided along the operating shaft. In such a device, provision is made for the individual guides to be formed into a common guide unit and for this a profiled post is used which extends over the whole working length of the shaft and is anchored therein. In this manner the space requirement, assembly and maintenance are reduced compared with known individual guides. Moreover, all guide parts may be located in a confined region on one side of the cabin only. The advantage of this is that three sides of the cabin remain free and are accessible to passenger and load traffic.

The steel straps are preferably guided substantially without clearance on the profiled post. By this means unnecessary operating resistances and noises during operation of the lift are avoided.

In strap lifts a further improvement is obtained in accordance with the invention in that the end fastening of the or each strap is formed as a clamping device which consists of a housing absorbing the fastening forces and tapering in the direction of the load, and a clamping wedge of the same taper as that of the housing and displaceable relative thereto, such that between the housing and the clamping wedge a pre-tension exists which is greater than the maximum operating tension. A plastically deformable clamping hood fitting closely to the inside wall surface of the housing is expediently located between the inside wall of the housing and the clamping wedge. During operation, forces can never occur in the end fastening which are greater than the pre-tension of the end fastening. This gives an operating safety adequate for all requirements. The pre-tension of the end fastening is independent of the lift operating load and even of no load at all. The pre-tension of the end fastening is maintained unchanged, so that even a reversal of force on the supporting strap is unable to have any effect on the fastening. Moreover, the pre-tension improves the permanent strength of the end connection. Since the

curvature of the central part of the clamping hood is that of the curvature of the clamping wedge the elastic limit of the strap is not exceeded. This is made possible in that the thickness of the clamping hood is 2 to 3 times as large as that of the spring steel strap and the rigidity accordingly being 8 to 27-fold value. Before inserting the clamping wedge, the strap end and the clamping hood are assembled together.

Several embodiments of the invention are shown by way of example in the accompanying drawings, in which:—

Fig. 1 is a schematic longitudinal section through an embodiment of the invention in the form of a strap lift in which a lift cabin and counterweight are suspended by a number of straps, a driving pulley being located above the cabin and counterweight;

Fig. 2 shows a view of an arrangement for fastening the load ends of the suspending straps shown in Fig. 1, which are located side by side;

Fig. 3 shows schematically a longitudinal section through a whole lift shaft and showing a lift in which all the operating means are combined in one operating unit mounted on the lift cabin;

Figs. 4*a*, 4*b* and 4*c* show diagrams of the loading or stressing of a supporting strap when pre-curved in a longitudinal direction;

Fig. 5 shows, on an enlarged scale, a cross-section through a steel strap and a pulley provided with a facing;

Fig. 6 shows a diagram of the longitudinal stresses in the strap;

Fig. 7 shows an emodiment of the invention wherein a lift cabin is suspended by two pairs of straps passed around a drive drum, one pair being arranged above the other, and wherein a parallelogram linkage is provided for compensating for the differences between the effective lengths of the individual pairs of straps which occur over the range of travel of the lift cabin;

Fig. 8 shows schematically the strap suspension and length compensating arrangement of Fig. 7, when the lift is half-way up the shaft;

Fig. 9 shows schematically the strap suspension and length compensating arrangement of Fig. 7, when the lift cabin is in its uppermost position;

Fig. 10 shows an embodiment of the invention in which a lift cabin and counterweight are supported by one or more straps, the driving pulley being located below the cabin and counterweight with consequent compressive stress in the or each strap;

Fig. 11 is a section taken on the line A—A of Fig. 10;

Fig. 12 shows on an enlarged scale a part section of the guide combination of Fig. 11;

Fig. 13 shows an arrangement for attaching the lift or counterweight to the one or more straps in the embodiment shown in Fig. 10;

Fig. 14 is a view of an end clamp for the spring steel strap of a passenger lift viewed in the direction of the arrow *x* in Fig. 15;

Fig. 15 is a cross-section taken on the line B—B of Fig. 14; and

Fig. 16 is a cross-section similar to that of Fig. 15 of a modified end fastening of the supporting strap.

The embodiment of the invention shown in Fig. 1 is a passenger lift comprising a lift cabin with counterweight. The supporting means include three spring steel straps 1 which, as shown in Fig. 2, are arranged side by side. Suspended on the spring steel straps 1 is a cabin 2, the weight of which is compensated by a counterweight 3. The straps 1 each have a width *a* which is many times greater than their thickness *t*. Due to tension imposed by the load and counterweight, the straps 1 are straight between a driving pulley 4, around which they are passed, and the cabin 2 and counterweight 3. Due to their flexibility, the straps curve readily around the driving pulley 4. The latter is provided with a friction covering 5. Drive means 6 for the pulley 4 is accommodated in a housing 7, which is mounted at the top of the shaft 8 of the lift. The fastening of the supporting straps 1 to the cabin 2 is shown in detail in Fig. 2.

In the embodiment shown in Fig. 3 all the operating means of a lift cabin, such as the drive, the gearing, the coupling, the brake, the control with associated leads and a drive pulley 9 are combined into one operating unit 10. The shaft 8 passes through a plurality of floors 11.

The spring steel strap 1 shown in Fig. 4*a* assumes a straight operating position when under tension. This is one of the limiting cases. The other limiting case is shown in Fig. 4*c*, where the strap 1 bends through an angle of 180° at a radius R_T. In Fig. 4*b* the bearing strap is shown pre-curved; it has a thickness *t* and a radius of bend R_{Π}. At this pre-curve the bending stress of the strap $\delta=0$. In case of Fig. 4*a* the stress δ has a value

$$\pm E\frac{t}{2R_{\Pi}}$$

In Fig. 4*c* the stress

$$\delta=\pm E\frac{t}{2}\;\frac{R_{\Pi}-R_T}{R_T\,.\,R_{\Pi}}$$

In these designations E denotes the modulus of elasticity, R_{Π} the radius of pre-curvature and R_T the smallest operating radius of curvature. The pulley is denoted by 56.

Particularly favourable conditions for the stressing of the strap are obtained if

$$R_u = 2 . R_r$$

In this case the stress for both limiting cases of curvature are the same; they are then

$$= \pm E \frac{t}{2 R_u}.$$

The action of the strap 1 is improved if, in addition to it being pre-curved in a longitudinal direction, it is convexly curved in a transverse direction. Such transverse curvature results in the edge regions 13 of the strap being subjected to compressive stresses, whilst the central region 12 is subjected to tensile stresses, as shown in Fig. 6. As shown in Fig. 5, the surface of a drive pulley 56 may be provided with a convex layer 14 and the transverse curvature of the strap 1 be shaped to conform to this. The stress distribution according to Fig. 6, which can be obtained by curvature of the strap 1 where it passes round the pulley due to its natural flexibility and/or due to a transverse pre-curving of the strap throughout its length, eliminates any tendency of the edges of the strap to crack.

In the embodiment of the invention shown in Figs. 7 to 9, a drive pulley 9 is used on which two juxtaposed (overlapping) pairs of steel straps 1 are wound and unwound, the pairs of steel straps being arranged one above the other. During operation, they form an angle α which varies between certain limits. In this embodiment, four thin, flat steel straps 1 are provided. The drive pulley 9 is driven on the axle 15. A drive unit (not shown) performs the drive.

Between the cabin 2 and the pulley 9, there is a length compensating arrangement 16. The purpose of this arrangement is to compensate for the differences between the effective lengths of the individual pairs of straps which occur over the range of travel of the lift cabin. These length differences are due to the winding of one strap over the other on the drive pulley 9. The length compensator 16 consists of a pedestal 17, which is secured to the cabin 2, and a parallelogram linkage consisting of two members 18, separately and pivotally connected to the pedestal 17, and two connecting members 19 to which the free ends of the members 18 are connected. The connecting members 19 are cranked at ends 20 remote from the members 18 and to each of said ends a respective one pair of the two pairs of straps 1 is clamped. The members 19 are cranked at the ends 20 so as to enclose an angle α, which is as small as possible. Where so clamped, the straps 1 are bedded in a soft material, e.g. rubber, so that the stressing of the fixing position is reduced to a minimum.

In the mid-position of the range of travel of the cabin 2 (Fig. 8) the distance between strap connections 20 is at its maximum. The angle α is at its smallest when the cabin 2 is in its lowermost position. When the cabin 2 is in the uppermost position (Fig. 9), then the angle α is somewhat larger than the angle α in the lowermost position of the cabin 2, but has assumed its minimum possible value and will coincide substantially with angle α in the centre position (Fig. 8).

Fig. 10 shows a lift arrangement in which a drive pulley 4 is located below a cabin 2 and a counterweight 3. The cabin 2 is located at one end 22 of one or more support straps 21. In a similar manner, the counterweight 3 is located at the other end of the support strap or straps 21, after rounding the pulley 4. The drive unit 6 with the drive pulley 4 is housed in an operating chamber 24 located below the shaft 8. The or each strap 21 is thus subjected to a compressive stress due to the load presented by the cabin and counterweight guides for the support strap or straps 21, cabin 2 and counterweight 3 are provided in the form of a continuous post 27. As will be seen later on, the strap or straps 21, although subject to compressive stress, is or are guided on all sides. The cabin and counterweight are thus supported by the strap or straps, and even in the event of strap breakage, an uncontrolled fall of the cabin or counterweight is not possible, because in such a case the two broken ends of the, or each, strap transmit the load and due to their guidance cannot slip past one another.

Fig. 11 shows the post 27 passing through a niche 25 in the cabin 2 and anchored by means of anchoring bolts 26 in the wall of the shaft 8.

The co-operation between guide members mounted on the cabin 2 and counterweight 3, on the one hand, and the post 27, on the other hand, is shown in detail in Fig. 12. Holding fittings 28 and 29 for the support strap 21 (assuming a single support strap is used) are located on the cabin 2 and on the counterweight 3 respectively. The guide post 27 locates guide rollers 31, arranged to run in tracks 30, for the cabin 2 and counterweight 3, and, in addition, guide rollers 32 to locate the support strap 21 and which engage the edges of the strap. The support strap is also guided in sliding linings 33 which are arranged on guide ledges 34 or the guide post 27. The guide ledges 34 are displaceable to a limited extent at right angles to the direction of movement of the support strap 21, so that whilst maintaining clearance and allowing for inaccuracies during operation, they are able to yield. This yielding ability is obtained from the resilient construction of carriers 35 for the adjustable guide ledges 34. An

adjuster bolt 36 is used for setting the pre-tension of the resilient carriers 35.

In Fig. 13, which shows a detail C of Fig. 10, a hinged support 39 is incorporated between the reinforced end 37 of the support strap 21 and the fitting 28 of the cabin 2, which permits compensatory movements in all directions between the support strap 21 and the cabin 2. This hinged support 39 is a solid rubber member or a spring. The guide rollers 31 for the cabin 2 are 1 located on the fitting 28.

Whilst the embodiments of the guide units or guide posts 27 shown hitherto are located to one side of the cabin 2, it is possible to arrange the guide units on both or opposite sides of the cabin 2. The weights 3 would then be located identically on both sides of the cabin 2.

Figs. 14 and 15 show end clamps for the spring steel strap 1. A clamp for a spring steel strap 1 which is thin relative to its width consists of a housing 40, a clamping wedge 41 with a facing layer 42, a clamping hood 43 and an additional strap safeguard 44. The housing 40 is a casting which is hollow inside and tapers downwardly in the direction of load y. The housing, the upper end 45 of which is hinged at 46 to the load e.g. a lift cabin, (not shown) is secured with bolts 47, and is pocket-shaped The clamping wedge 41 is inserted in the housing 40 together with the facing layer 42, the clamping hood 43 and the strap end of the steel strap to be secured. The end of the steel strap is clamped between the clamping hood 43 and the facing layer 42 of the clamping wedge 41. Clamping force is applied to the strap which is greater than the maximum tension experienced during the operation of the supporting strap 1. The pre-tension obtained in this manner is maintained independently of the operating tension by bending the ends 48 of the clamping hood 43 around the lower edge 49 of the housing 40. This forms the whole end fastening into a locked unit, the pre-tension of which remains unchanged even if an operating state occurs which causes a complete slackening of the supporting strap. This slackening could otherwise affect the end fastening itself. During the bending over of the ends 48 of the clamping hood 49 of the housing 40 a suitable pressure is exerted on the clamping wedge 41. This may be effected by means of a clamping jaw 50. After effecting the connection, the clamping jaw 50 is removed without reducing pre-tension in the end fastening.

The additional strap safeguard 44 consists of a bolt 51 the front end 52 of which is provided with a point. The bolt engages in a holding stirrup 53 which is slid over the end of the supporting strap 1 projecting from the fastening. This is so effected that the holding stirrup 53 after being slid over the end of the strap abuts tightly against the bent-over edge 48 of the clamping hood 43. The bolt 51 is now driven into the end of the strap thus producing an edge 54. Into this edge the shaft 52 of the screw bolt 51 is inserted. This produces the additional safeguard.

The end fastening is structurally so formed that the load direction y of the supporting strap 1 coincides with the direction z of the point of suspension 46.

In a modified embodiment of the end fastening shown in Fig. 16, the supporting strap 1 is clamped directly between the inside wall of the housing 40 and the clamping wedge 41 and is provided with the necessary pre-tension. A screw 55 is used to maintain the pre-tension, by means of which the clamping wedge is clamped tightly in the pocket of the housing 40. As an additional safeguard against slippage of the fastening an additional strap safeguard 44 as shown in the embodiments of Figs. 14 and 15 is used.

WHAT I CLAIM IS:—

1. Apparatus for lifting and/or lowering loads, comprising a load carrier supported by means of at least one thin, flexible, spring steel strap passed round and driven by a drive pulley, drum or rollers coupled to drive means.

2. Apparatus according to claim 1 in which the load carrier is a lift cabin, wherein the means necessary for operating the lift cabin are combined in an operating unit located on the roof of the lift cabin.

3. Apparatus according to claim 1 or 2, wherein the or each spring steel strap is pre-curved in a longitudinal direction.

4. Apparatus according to claim 3, wherein the radius of the pre-curvature (R_{II}) of the spring steel strap is the same as or greater than the radius of curvature (R_T) of the pulley, drum or rollers over which the steel strap passes.

5. Apparatus according to any one of claims 1 to 4, wherein the or each steel strap, when passing over the pulley, drum or rollers has a transverse curvature, said curvature resulting from the cónfiguration of the pulley, drum or rollers and/or from the application of a transverse pre-curving to said strap.

6. Apparatus according to any one of claims 1 to 5, wherein a plurality of steel straps are passed over pulleys and each pulley has a friction layer round its circumferential surface, said layer ensuring adequate running and operation of the associated strap.

7. Apparatus according to any one of claims 1 to 6, wherein the load carrier is suspended by a plurality of steel straps arranged flat one over the other on the drive pulley, drum or rollers and means are provided for compensating for the differences between the effective lengths of the individual straps—which occur over the range of travel

of the load carrier, said differences being due to the winding of one strap over the other on the drive pulley or drum.

8. Apparatus according to claim 7, wherein said plurality of straps comprises two pairs of straps, one pair being arranged flat over the other pair, and said length compensating means comprises two parallel members of a parallelogram linkage separately and pivotally mounted on a portion of the load carrier, the two other members of said linkage each being connected to the load ends of a respective one pair of the two pairs of straps.

9. Apparatus according to claim 1, wherein a lift cabin and a counterweight are supported by one or more straps with a drive pulley located below the cabin and counterweight, the cabin and counterweight being lifted and/or lowered by the strap or straps within a shaft and individually guided, with said strap or straps, within the shaft by guides combined in a common guide unit comprising a profiled post extending over the whole operational length of the shaft and anchored in the shaft.

10. Apparatus according to any one of claims 1 to 7, wherein the load carrier and a counterweight are lifted and/or lowered within a shaft and are individually guided within the shaft by guides combined into a common guide unit comprising a profiled post extending over the whole operational length of the shaft and anchored in the shaft.

11. Apparatus according to claim 9 or 10, wherein the steel straps are guided substantially without clearance on the profiled post.

12. Apparatus according to any one of claims 1 to 11, wherein the end fastening of the or each strap on the load carrier is formed as a clamping coupling comprising a housing tapering in the direction towards the load carrier and absorbing the fastening forces and a clamping wedge having the same taper as the taper of the housing and displaceable relative thereto and provided with a facing layer therebetween, the or each steel strap being clamped between the facing layer and the housing with a pre-tension greater than the maximum operational load.

13. Apparatus according to claim 12, comprising a clamping hood located between the inside wall of the housing and the or each steel strap, said clamping hood being plastically deformable and abutting said housing wall closely.

14. Apparatus for lifting and/or lowering loads, substantially as hereinbefore described with reference to the accompanying drawings.

POTTS, KERR & CO.

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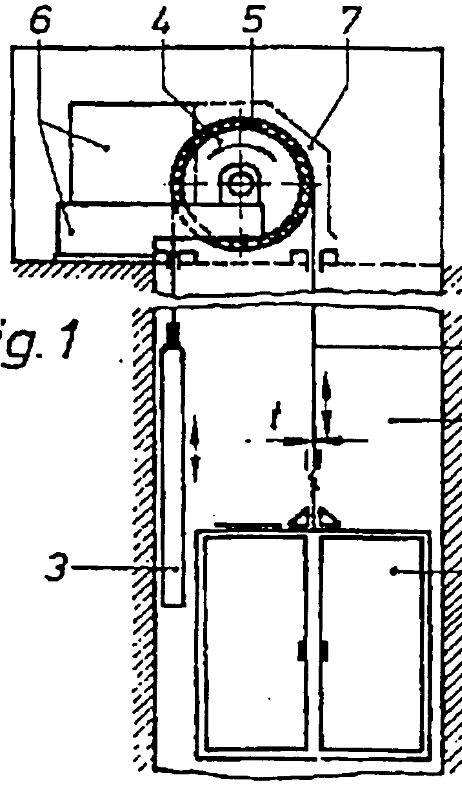

Fig. 1

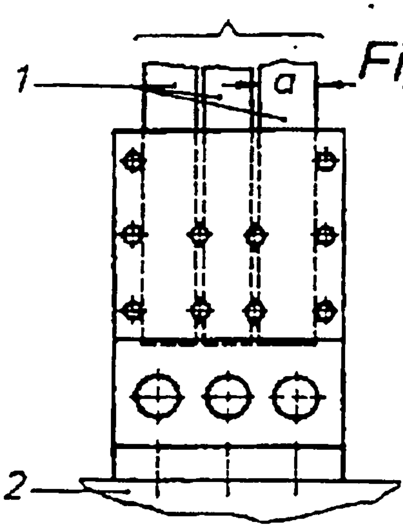

Fig. 2

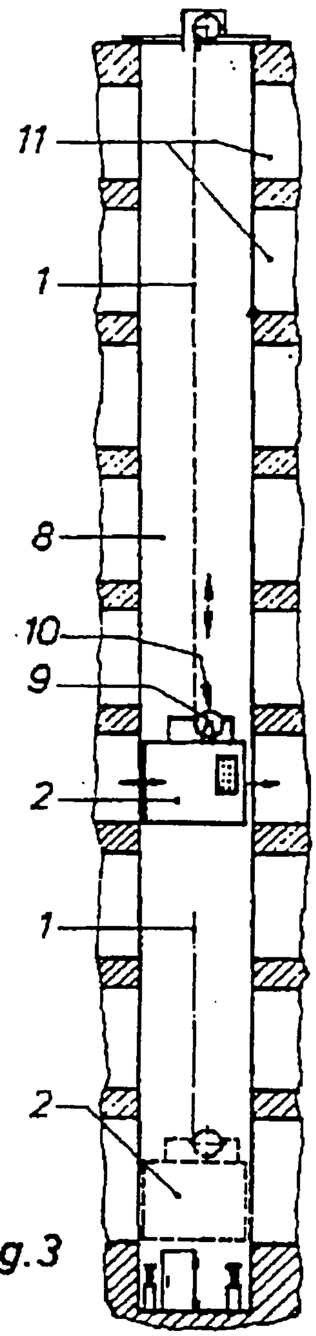

Fig.3

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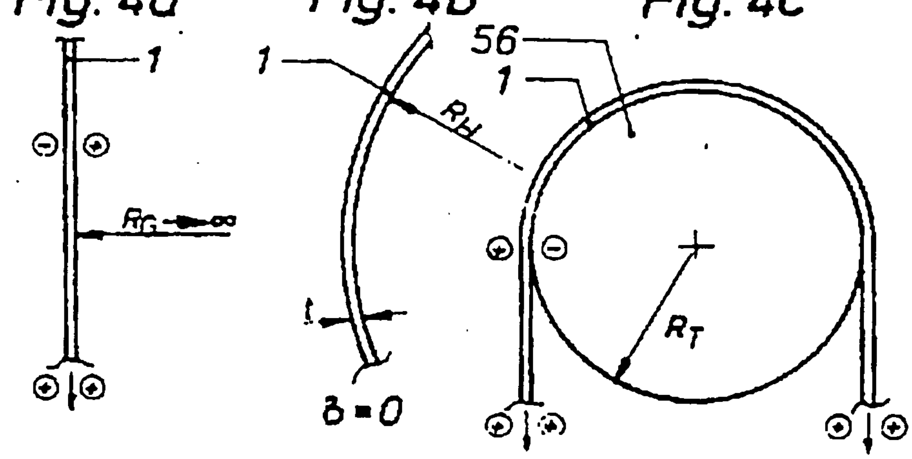

Fig. 4a Fig. 4b Fig. 4c

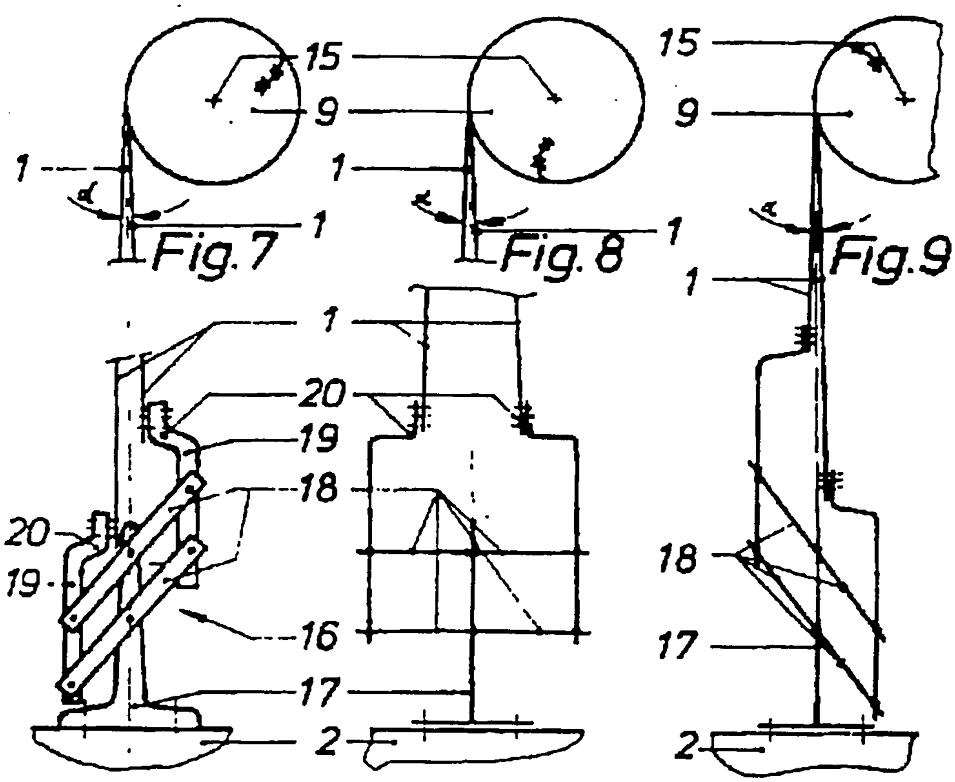

Fig. 7 Fig. 8 Fig. 9

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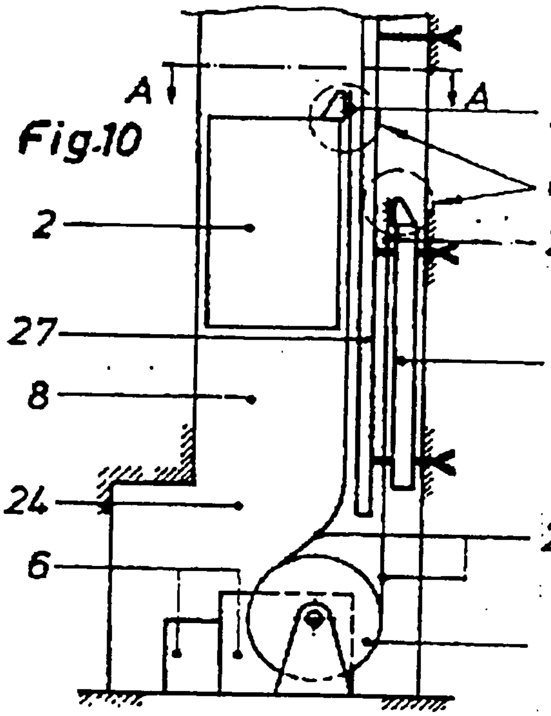

Fig.10

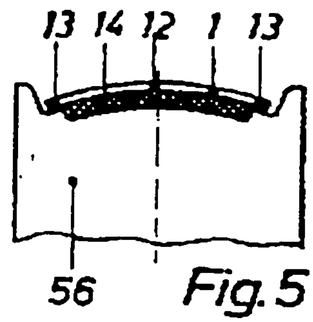

Fig.5

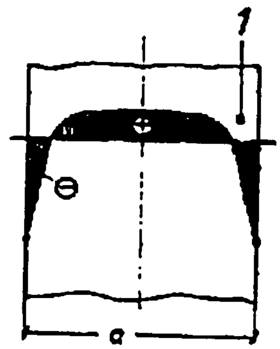

Fig.6

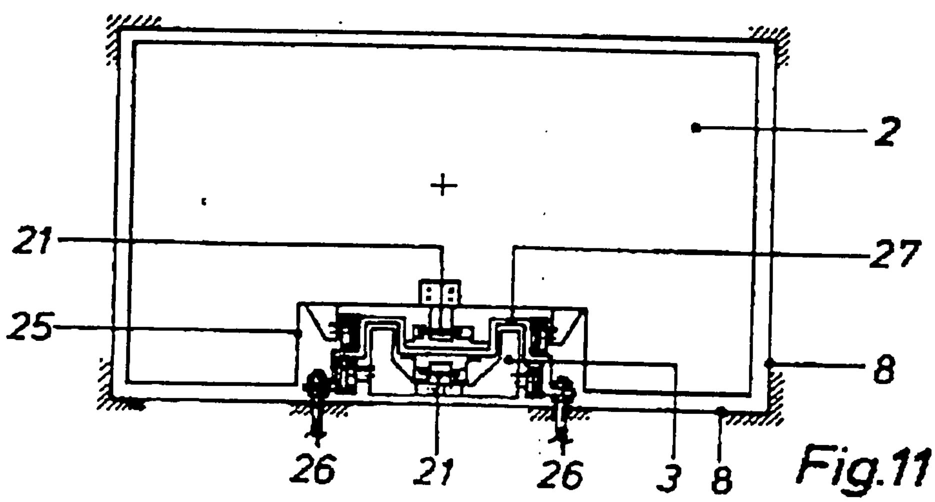

Fig.11

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Sheet 4

Fig. 12

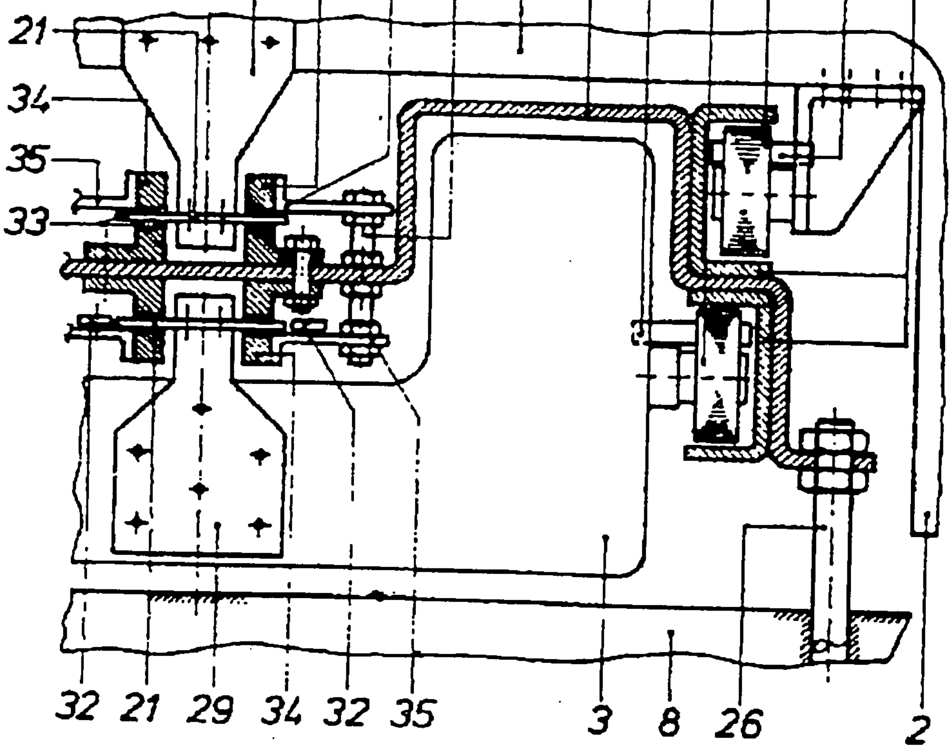
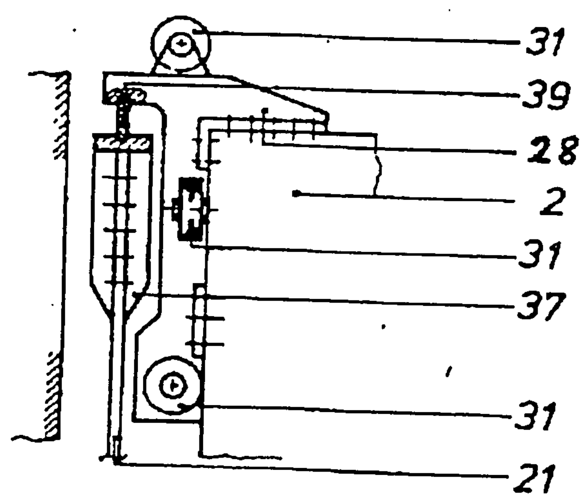


Fig. 13



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Sheet 5

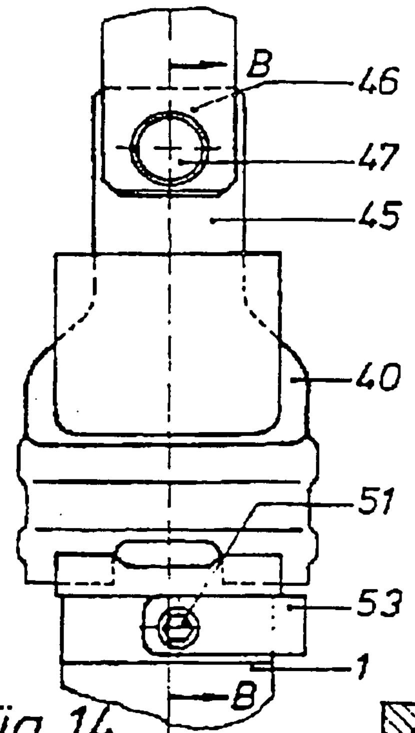

Fig. 14

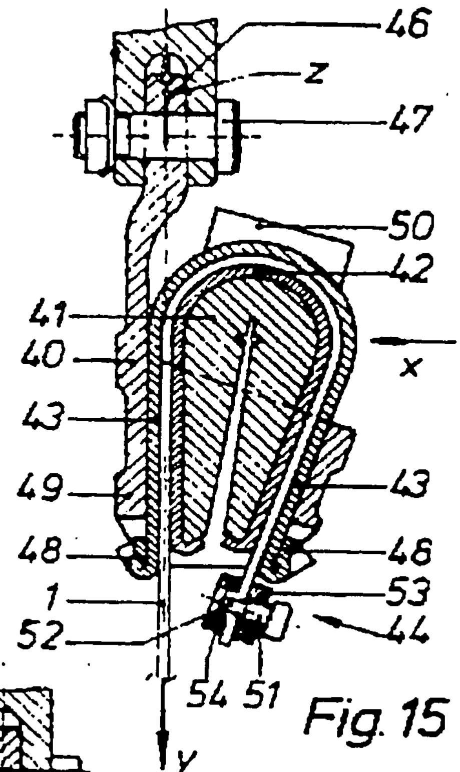

Fig. 15

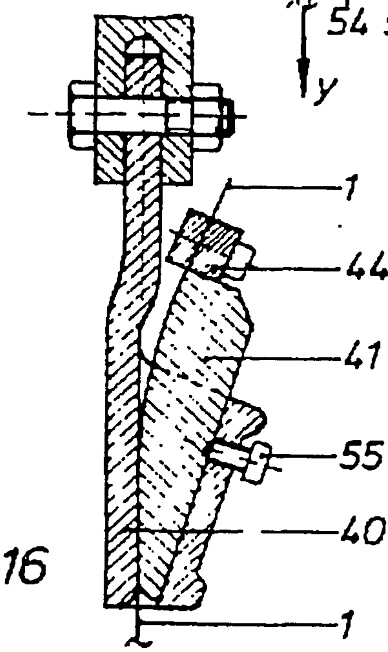

Fig. 16